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Indian Standard

INTERNAL COMBUSTION ENGINES — RADIATOR FANS — SPECIFICATION

UDC 621·43-714·75

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BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

April 1991 **Price Group 3**

Automotive Prime Movers Sectional Committee, TED 2

FOREWORD

This Indian Standard was adopted by the Bureau of Indian Standards, after the draft finalized by Automotive Prime Movers Sectional Committee had been approved by the Transport Engineering Division Council.

Radiator fans form an integral part of the cooling systems of any internal combustion engine. The efficiency of the system depends mainly on the forced draught provided by the fans. Together with the water pump the fans increase or decrease the efficiency of the cooling circuit of the engines.

This standard forms an important adjunct to the standard on radiators, radiator pressure caps and the methods of test for radiators.

In the preparation of this standard assistance has been derived from SAE 635 'Fan hubs, bolt circles and pilot holes'.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

INTERNAL COMBUSTION ENGINES — RADIATOR FANS — SPECIFICATION

1 SCOPE

1.1 This standard covers the general requirements, preferred dimensions and the methods of test for sheet metal radiator fans.

2 REFERENCE

IS No.	*Title*
513 : 1985	Cold rolled low carbon steel sheets and strips (*third revision*)

3 NOMENCLATURE

The nomenclature shall be as given in Fig. 1 and Fig. 2.

4 MATERIAL

4.1 The fan blade and spider shall be made from cold rolled carbon steel sheet quality D as per IS 513 : 1986.

5 CONSTRUCTION

5.1 The individual blades shall be separately formed and riveted to the spider.

5.2 Single piece sheet metal pressings with suitable ribs for rigidity may also be used.

6 DESIGN REQUIREMENTS

6.1 The projected width of the blade and the chord angle shall be chosen to attain the maximum efficiency.

NOTE — Low chord angles and width of the fan blades are normally desirable for higher efficiency.

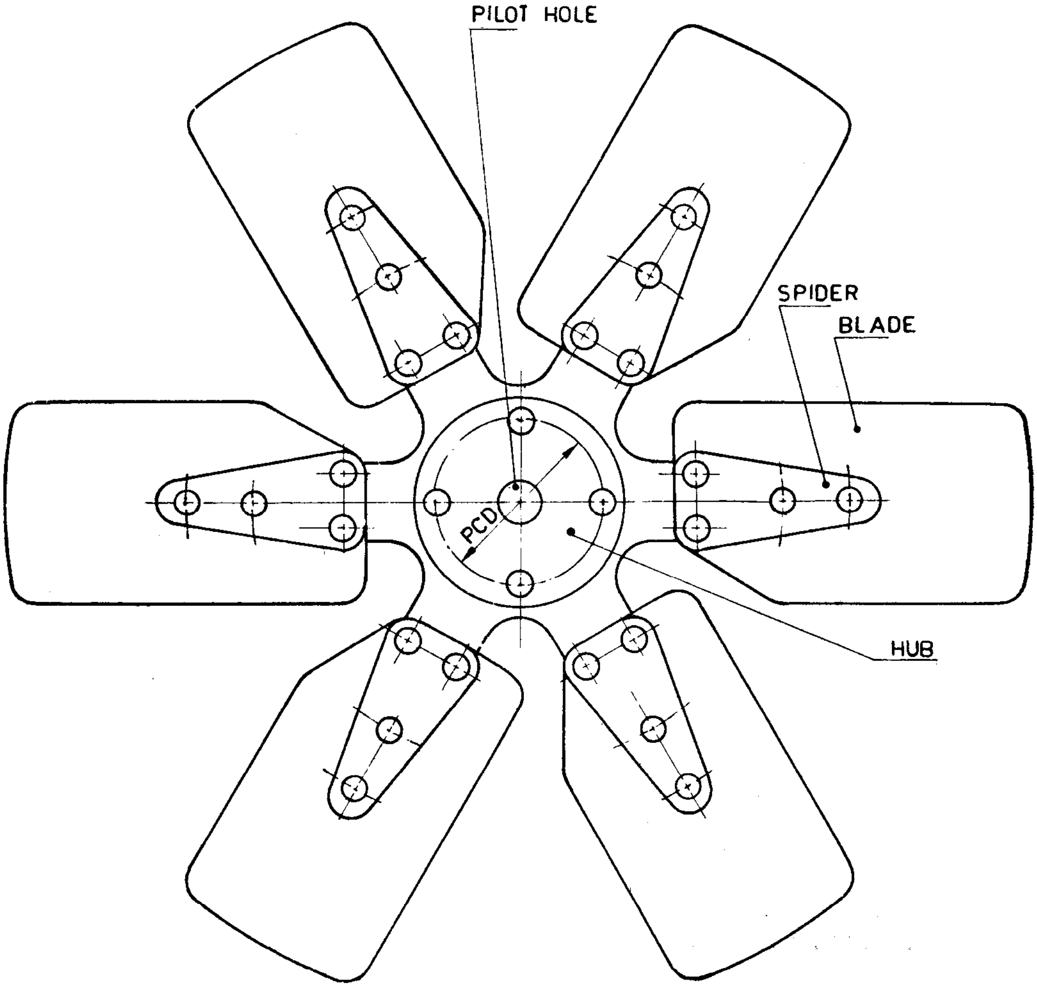


FIG. 1 NOMENCLATURE OF SHEET METAL FAN

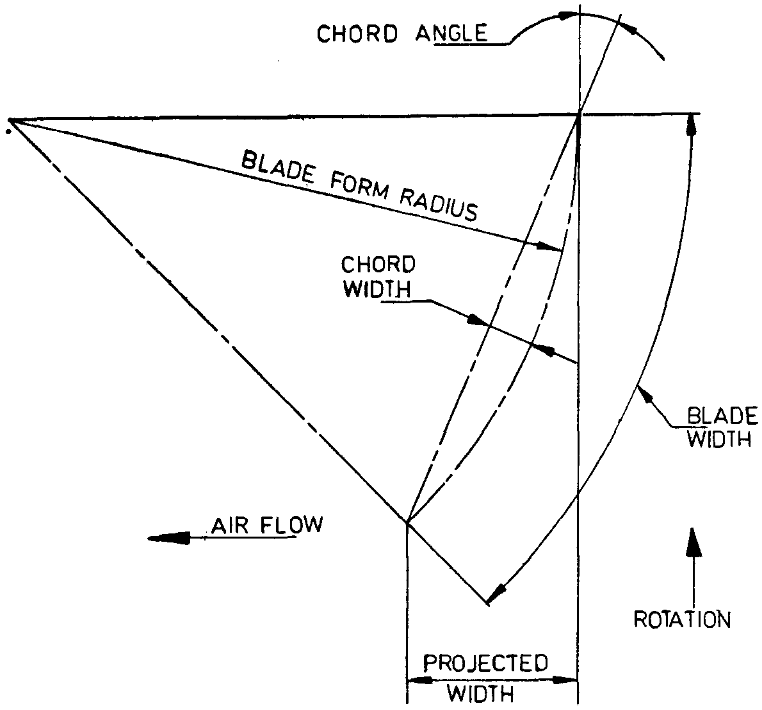


FIG. 2 ELEMENTS OF FAN BLADES

6.2 The grain flow of the sheet metal shall be continuous and in the longitudinal direction of the blades.

7 DIMENSIONS

7.1 The preferred dimensions of the fan shall be as given in Table 1.

Table 1 Preferred Dimensions of Radiator Fans

Engine Power	Fan Dia	No. of Blades	Thickness of Fan Blade	Thickness of Spider Material
kW	mm		mm	mm
7·5 to 22·5	290/350	4	1·00	2·50
22·5 to 40·0	350/450	4 to 6	1·28	3·20
40·0 to 85·0	450/540	6	2·00	3·50

7.2 The fan hub bolt circles dia and the pilot hole dimensions shall conform to Table 2.

8 TESTS

8.1 Type Tests

Type tests shall be carried out on all new designs or after major modifications to existing designs to establish their suitability for performance and structural strength. The following shall comprise the type tests :

a) Fan performance (*see* Annex A), and
b) Fan life tests (*see* Annex B).

Table 2 Mounting Dimensions of Radiators Fans

(*Clause* 7.2)

Fan Dia	Bolt Circle Dia (PCD)	No. of Bolts	Bolt Hole Dia	Fan Pilot Hole Dia	Hub Pilot Hole Dia	Bolt Dia
mm	mm		mm	mm	mm	mm
Up to 600	50	4	8·75	25·00	24·95	8
600 to 1 000	100	6	10·75	50·00	49·95	10
1 001 to 1 600	150	6	12·75	75·00	74·95	12
1 601 to 2 000	200	8	12·75	100·00	99·95	12

9 MARKING

9.1 Radiator fans shall be marked with the indication of the source of manufacture, trademark, fan diameter, and engine power.

10 PACKING

10.1 The fans shall be packed suitably after treating with anti-corrosive material.

11 SAMPLING

11.1 For the purpose of testing radiator fans the sampling plan shall be for various tests as agreed between the purchaser and the manufacturer.

ANNEX A

[*Clause* 8.1 (a)]

FAN PERFORMANCE TEST

A-1 GENERAL

This test shall be carried out on the fans to determine the flow characteristics and power consumed at various speeds and static pressures.

A-2 DEFINITIONS

Mechanical Efficiency — The ratio of power output of the fan to the power input to the fan, expressed as percent.

Absorption Power — The power required to drive a fan at zero efficiency and free of all obstructions and air flow affecting devices.

A-3 TEST RIG

The test equipment shall be set up in accordance with Fig. 3.

A-4 LOCATION

The fan shall be located in the radial and axial centre of a sharp edge orifice which is the exit of the plenum chamber as shown in Fig. 3. There shall be no artificial simulation or any other obstruction to the cooling air flow by radiator, pulleys. Unless otherwise agreed to, the orifice diameter shall be equal to the fan diameter+38 mm.

A-5 TEST INSTRUMENTS

Pressure Recording Instruments — A liquid in glass manometer or inclined manometer shall be used for measuring static and differential pressures and velocity.

Power Measuring Instruments — Dynamometer of cradle type motors or torsion meter properly calibrated are recommended for all power measurements.

Speed Measuring Instruments — Tachometers, stroboscopes shall be used for recording speed and shall have an accuracy with ± 1% of the value being measured.

Thermometers — The temperature measuring devices shall be calibrated to an accurary of ± 0·5 °C or finer.

A-6 PROCEDURE

The fan shall be set up with the recording instruments as shown in Fig. 4. The inlet to auxiliary fan shall remain closed. The dynamometer shall be started and the fan allowed to attain a speed of 500 revolutions per minute. The test fan is allowed to stabilize at 500 rpm for at least 30 s. The following recordings shall then be made:

a) Total pressure at plane 4

b) Static pressure at plane 3

c) Dry bulb temperatures at planes 3 and 4

d) Power input after speed has regulated to within ± 1% or within 10 revolutions per minute whichever is less.

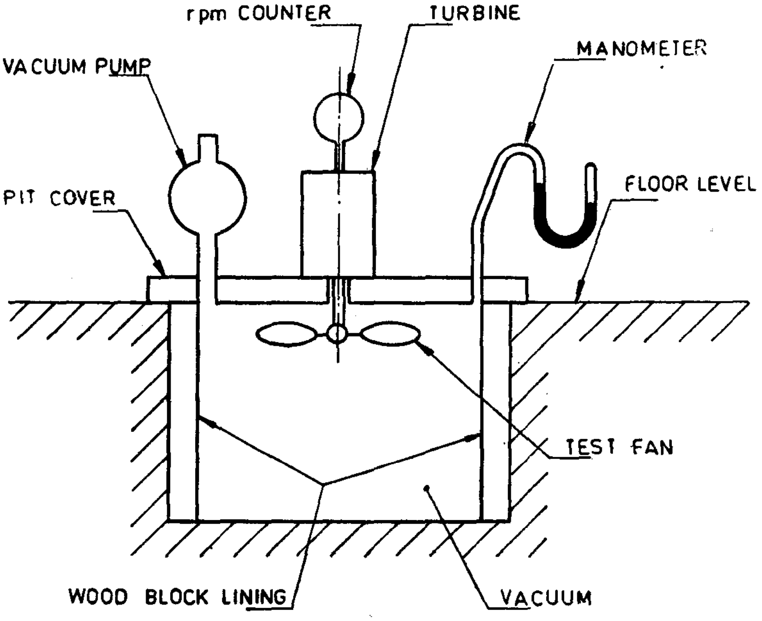


FIG. 3 TYPICAL SPIN TEST FACILITY

In addition, the barometric pressure in the test area and the dry and wet bulb temperatures in the path of the inflowing air shall be recorded. The inlet to the auxiliary fan shall be opened and suitable flow measuring orifice installed, after discontinuing the test temporarily. The test fan shall be started and allowed to stabilize at a speed of 300 revoiutions per minute. The auxiliary fan shall be started. The air pressure in the chamber shall be varied by adjusting the supply fan speed or using a throttle device at the inlet to attain a different point of rating for the test fan. A sufficient number of points shall be taken to fully define the curve from full flow to zero delivery. The dry and wet bulb temperatures, pressures in the planes 3 and 4, power input and barometric pressures in the test area shall be recorded. The test fan shall be tested at 2 000 rev/min and 3 000 rev/min and at any other additional speeds as required to define the fan characteristics fully.

NOTE — Two or more different size inlet air orifices may be required for the higher air flows due to higher operating speeds.

A-7 CALCULATION

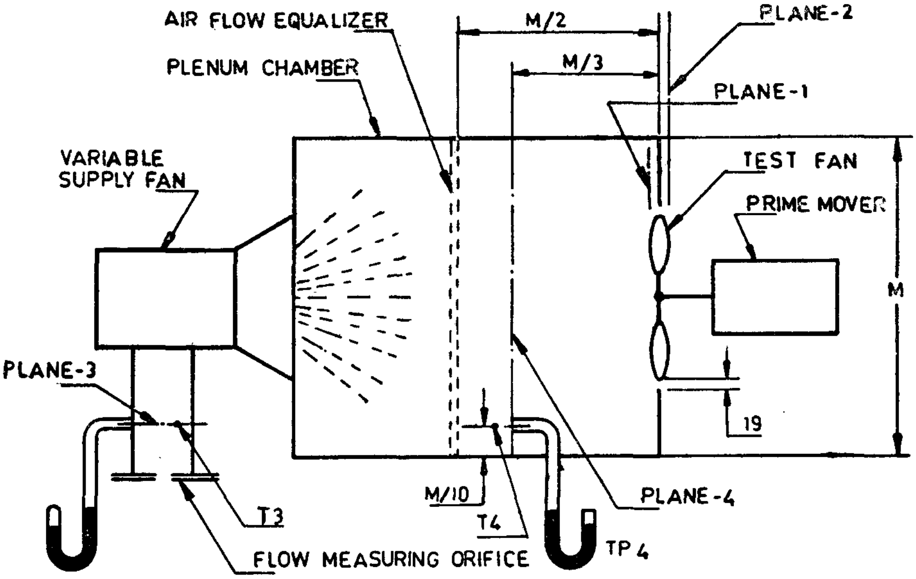
$$\text{Static efficiency} = \frac{\text{Air flow} \times \text{static pressure}}{\text{Power}}$$

where air flow is expressed in m³/s, static pressure in kN/m² and power in kW.

A-7.1 Corrections for Pressure Readings

Inclined manometer readings shall be corrected for calibrations in case the correction exceeds 0·3 mm. The manometer readings shall be corrected for calibration in case the correction exceeds 1·3 mm. The observed barometric pressure shall be corrected to the standard temperature conditions of 273 K.

At constant speed the power and the pressure are directly proportional to the air density. The power and pressure shall be corrected by using the multiplying factor $\frac{1 \cdot 2}{d}$, where d is the air density at 20°C at fan inlet in kg/m³.



$TP_1 = TP_4$ $\qquad V_2 = \frac{m^3/mt.}{A_2}$

$m^3/mt = m^3/mt_1 = m^3/mt_3 \, \frac{d_3}{d_1}$

$m^3/mt_3 = 242 \times Ca.\ A_3\sqrt{SP_3}$ $\quad TP_2 = VP_2$

$TP = TP_2 - TP_1$

$TP = VP_2 - TP_4$ (Algebraic)

$VP = VP_2 = \frac{V_2^2}{242} \times \frac{d_2}{1 \cdot 2}$

$SP = TP - VP = TP_4$

$m^3/mt = m^3/mt_1$

where

TP = Total pressure (mm of water)
VP = Velocity pressure (mm of water)
SP = Static pressure (mm of water)
T = Dry bulb temperature (°C)
V = Velocity (m/sec)
d = Density (kg/m³)

FIG. 4 FAN TEST FACILITY

A-7.2 Air Flow Volume

The volume of air passing through the system shall be determined from the static pressure drop across the orifice plate from the calibration chart or by calculations as follows:

$$\text{Air flow} = 242 \times Ca \times A \times h$$

where

Ca = the coefficient of entry;
A = the area of orifice, m^2; and
h = the static pressure, mm of water.

A-8 RESULTS

The fan performance data shall include the following characteristics;

a) Fan speed in revolutions per minute;
b) Input power, kW;
c) Air flow in cubic metres/second corrected to standard air density;
d) Static pressure across fan; and
e) Ambient conditions in the test area.

The results shall be calculated for the following test points:

a) Air flow,
b) Fan speed,
c) Fan input power,
d) Static pressure,
e) Mechanical efficiency, and
f) Static efficiency.

The test results shall be plotted for specific performance of the fan. The static pressure and input power against the airflow in cubic metres/second at stabilized speed at 2 000 and 3 000 revolutions per minute speeds shall be plotted. Figure 5 shows a typical graph.

The computations for 2 000 and 3 000 rpm can be interpolated after calculating for 1 000 rev/min.

Computed air flow

$$= \frac{\text{Computed speed} \times \text{Airflow (test)}}{\text{Test speed}}$$

Computed power

$$= \frac{\text{Computed speed} \times \text{Test power}}{\text{Test speed}}$$

Computed static pressure

$$= \frac{\text{Computed speed} \times \text{test static pressure}}{\text{Test speed}}$$

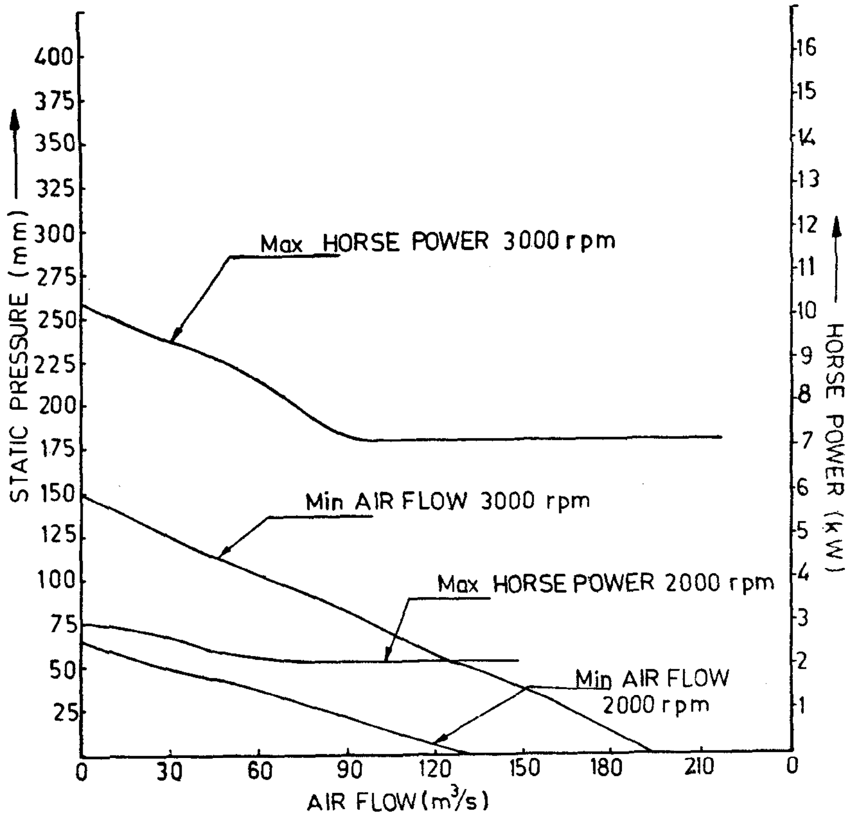


FIG. 5 TYPICAL GRAPH FOR THE PERFORMANCE OF A SHEET METAL FAN (STATIC AND INPUT HORSE POWER v/s AIR FLOW AT CONSTANT SPEED)

ANNEX B

[*Clause* 8.1 (b)]

FAN LIFE TESTS

B-1 GENERAL

This shall be conducted to establish a minimum margin of safety for structural strength of an engine cooling fan.

B-2 EQUIPMENT INSTALLATION AND ADJUSTMENT

The test equipment shall include a high vacuum spin test pit with associated equipment to control and measure fan speed within ±10 rev/min simultaneous with a vacuum of 50 mm of mercury, (absolute). The test pit shall be constructed so as to withstand shock due to fan disintegration at high speeds.

B-3 PROCEDURE

The maximum pitch at constant radial distance from each blade shall be measured. (Gauge radius is approximately 65 percent of fan radius).

The fan shall be mounted on the driving hub and the bolts tightened with a torque wrench up to 220 Nm torque. The fan shall be inserted into the pit and a vacuum of 50 mm of mercury absolute created in the test pit. The fan shall be started and allowed to stabilize at a speed of 3 000 revolutions per minute for 30 seconds. The speed of the fan shall be slowly increased from 3 000 to 6 000 revolutions per minute in steps of 500 rev/min and the speed stabilized for at least thirty seconds before increasing further. In case of excessive vibrations during the test the test shall be stopped immediately and restarted with a new fan assembly. The speed shall be reduced to zero after stabilizing at 6 000 rev/min for at least one minute.

B-4 POST TEST INSPECTION

The fan on inspection after the test shall not have any cracks or major visible structural deformations. The pitch of each blade at the same gauge radius, as measured prior to the test, shall be recorded for reference and comparison.

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